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Yoon

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(54) **SECONDARY BATTERY**

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(73) Assignee: **Samsung SDI Co., Ltd.**, Yongin-si (KR)

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H01M 2/12 (2006.01)

(52) **U.S. Cl.**
CPC ***H01M 2/0404*** (2013.01); ***H01M 2/0473*** (2013.01); ***H01M 2/1229*** (2013.01); *H01M 2/0469* (2013.01); *H01M 2/1241* (2013.01)

(58) **Field of Classification Search**
CPC H01M 2/0404; H01M 2/1229; H01M 2/0473; H01M 2/0469; H01M 2/1241
USPC 429/53, 82, 174, 175, 179, 185, 181
See application file for complete search history.

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(57) **ABSTRACT**

A secondary battery capable of preventing an internal electric short by allowing an upper cap plate to be deformed toward the outside of a can and having improved stability under external impacts. The secondary battery includes a can having an internal space, an electrode assembly inserted into the space of the can, and a cap plate coupled to a top portion of the can, wherein the cap plate includes a deformation inducing part having a groove formed on its one surface.

21 Claims, 9 Drawing Sheets

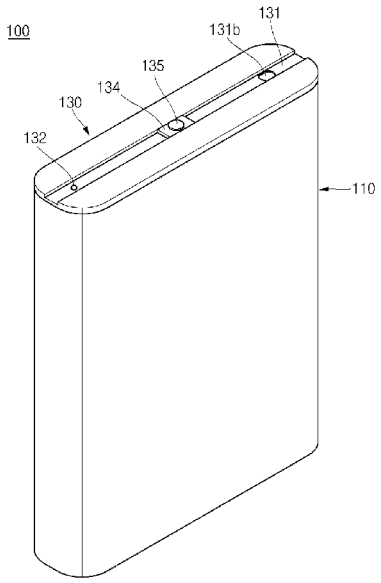


FIG. 1

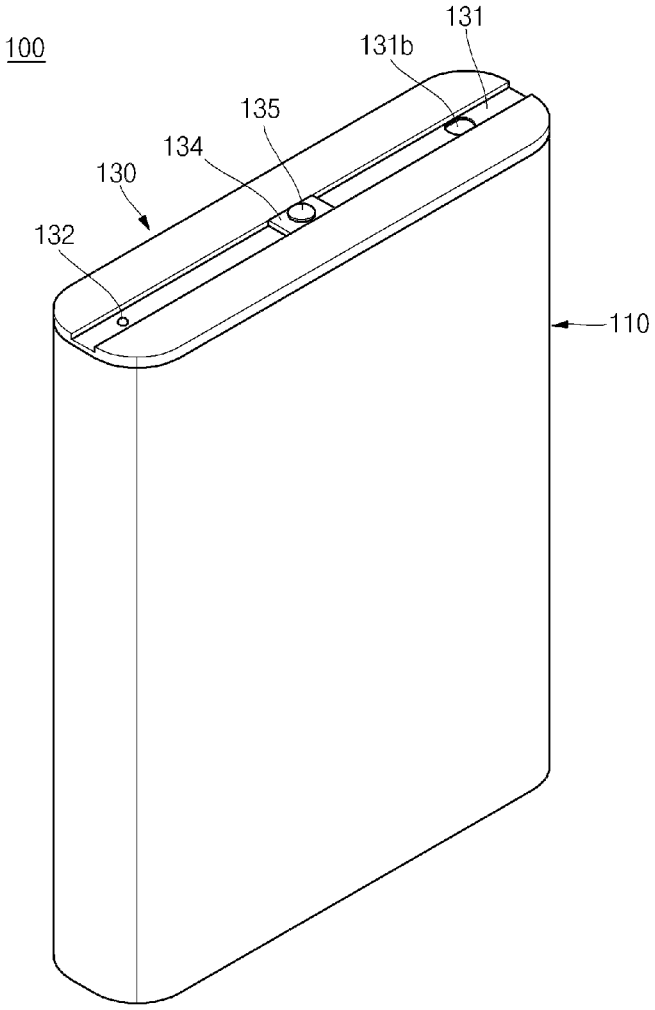


FIG. 2

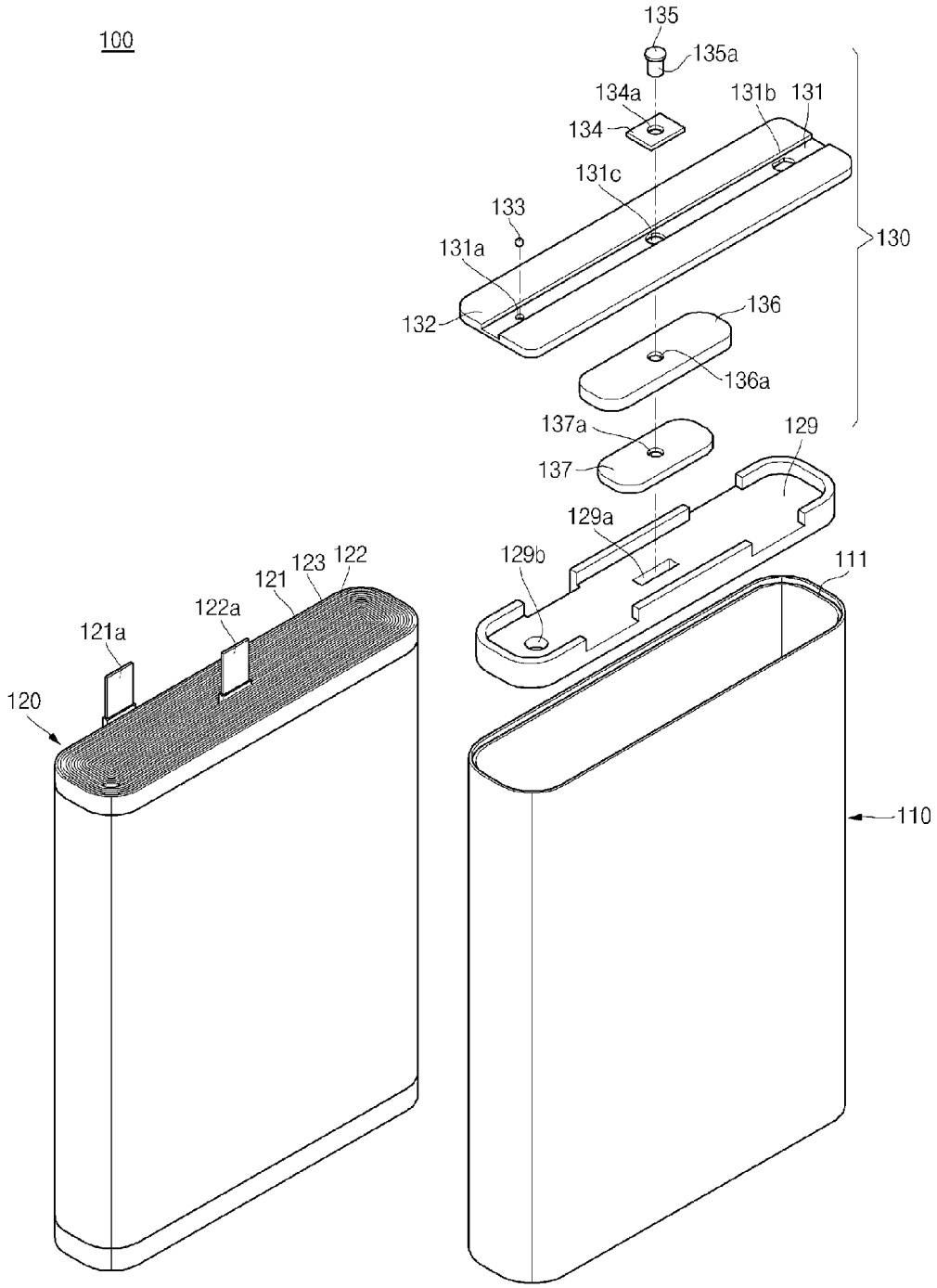

100
135
135a
134a
131b
131
134
131c
133
131a
130
132
136
136a
137a
129
137
129a
129b
111
123
122
121
122a
121a
120
110

FIG. 3

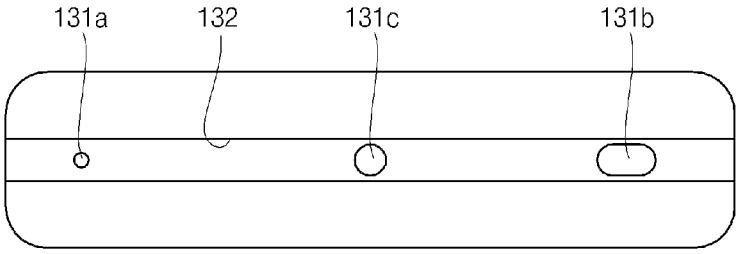


FIG. 4

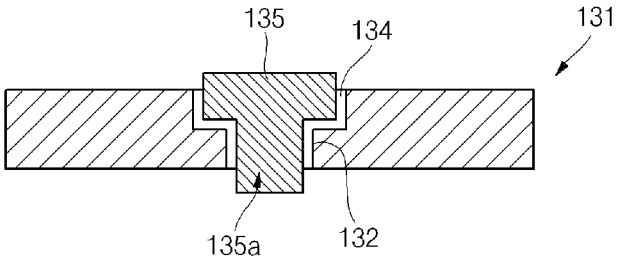


FIG. 5A

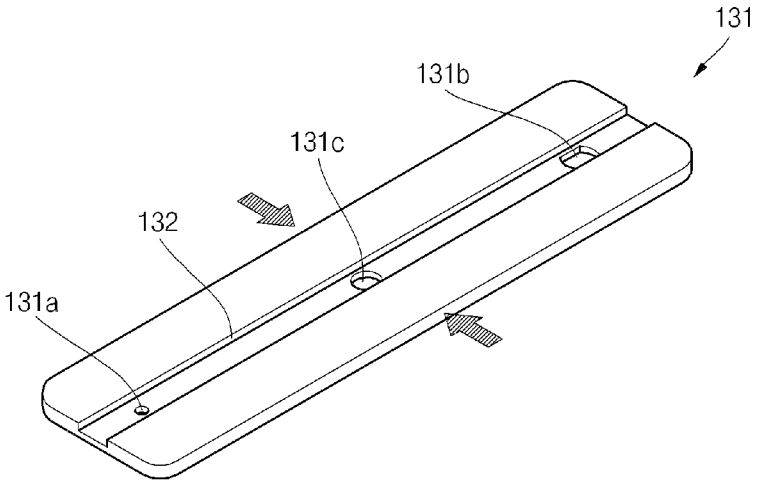


FIG. 5B

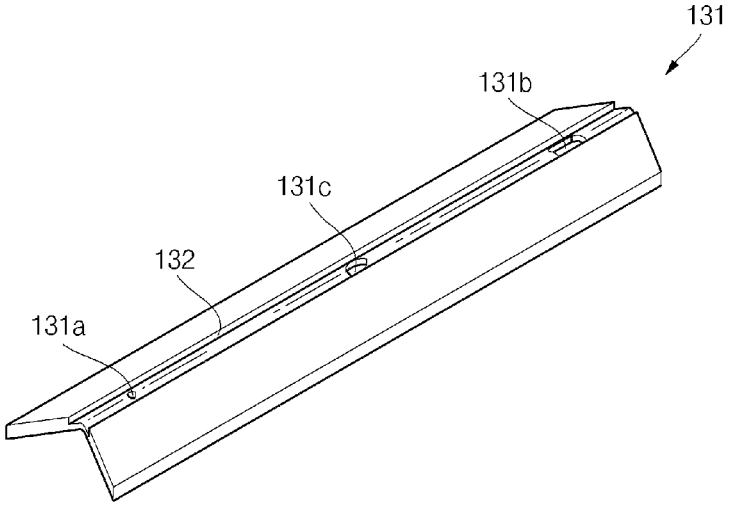


FIG. 6

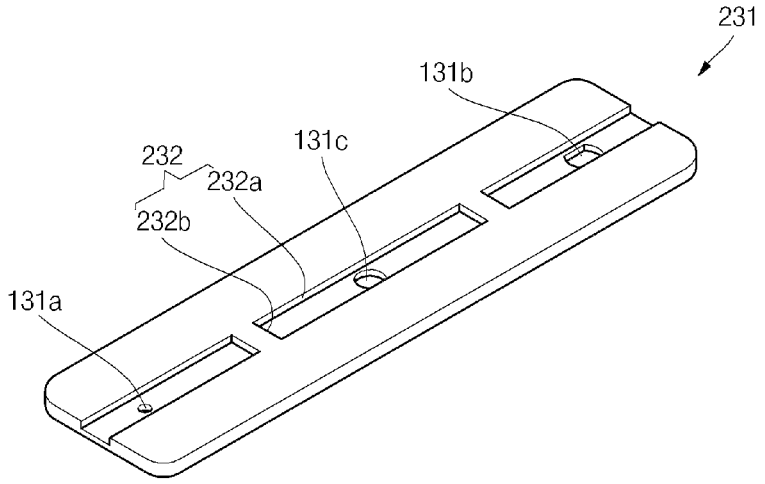

231
131b
131c
232
232a
232b
131a

FIG. 7

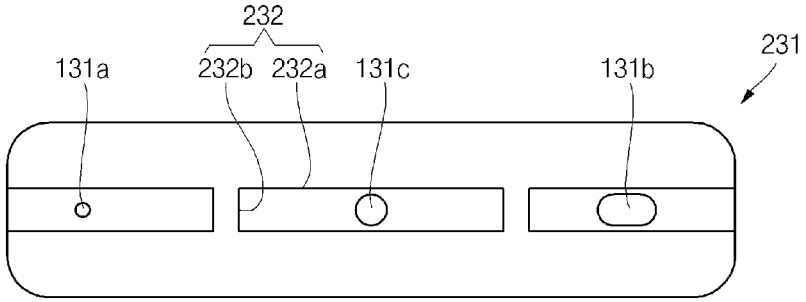

232
231
131a
232b
232a
131c
131b

FIG. 8

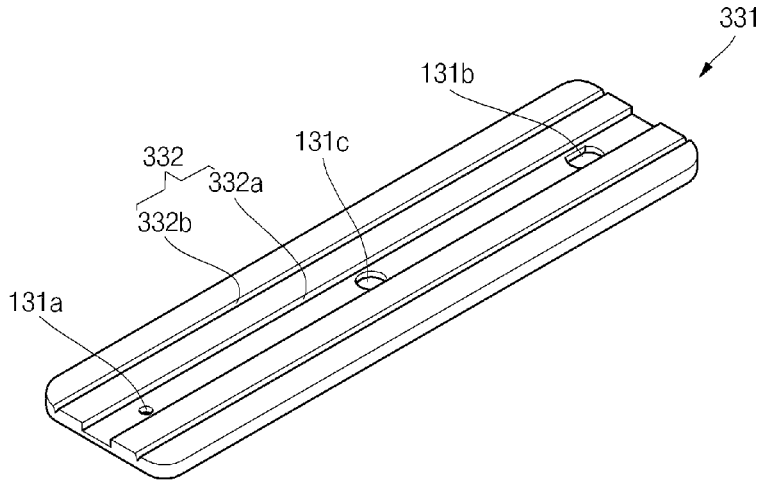


FIG. 9

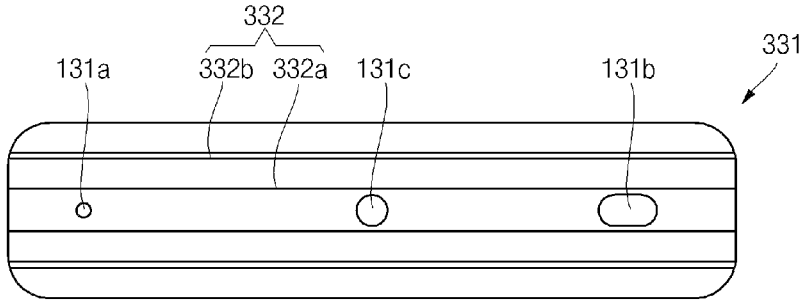


FIG. 10

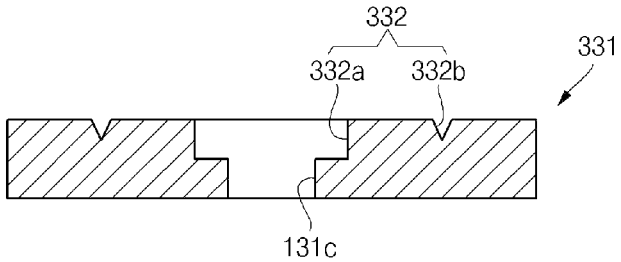


FIG. 11

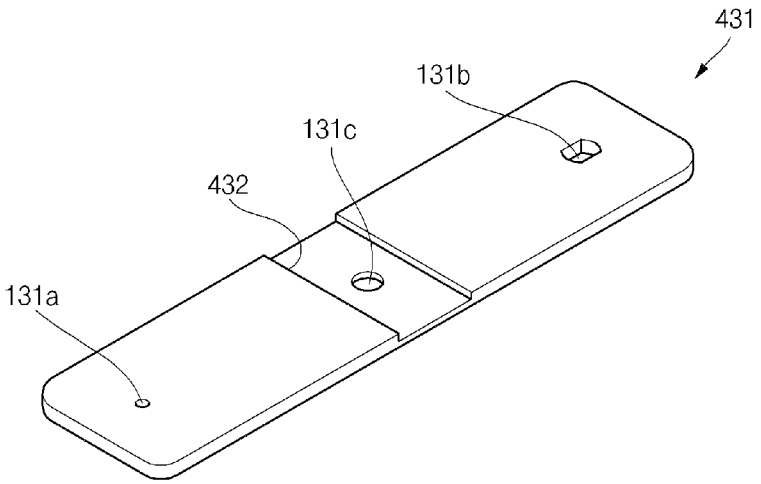


FIG. 12

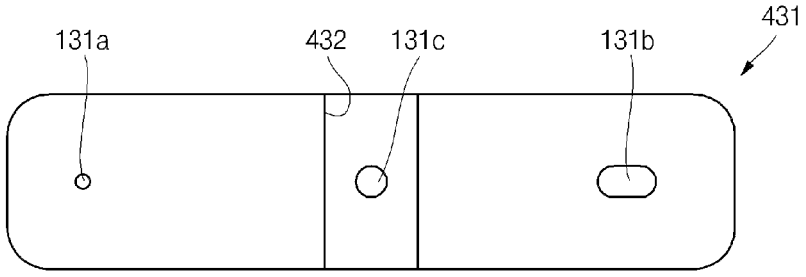


FIG. 13

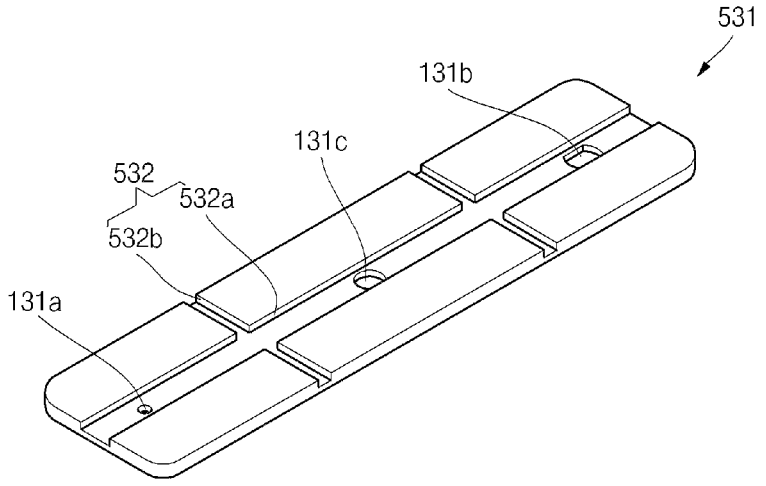

531
131b
131c
532
532a
532b
131a

FIG. 14

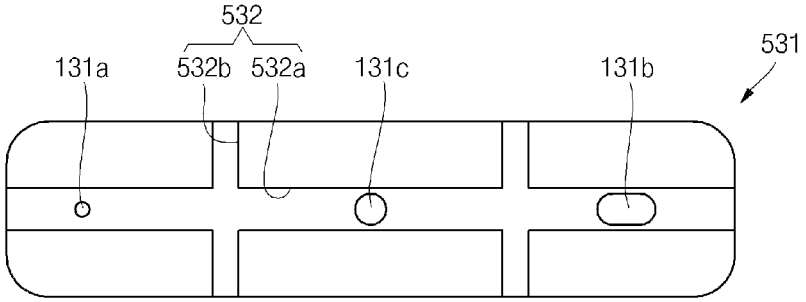

532
131a
532b
532a
131c
131b
531

FIG. 15

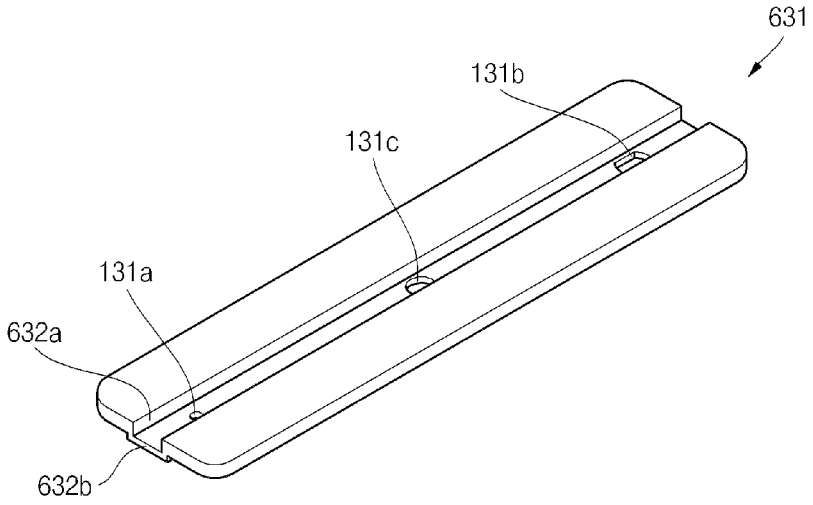
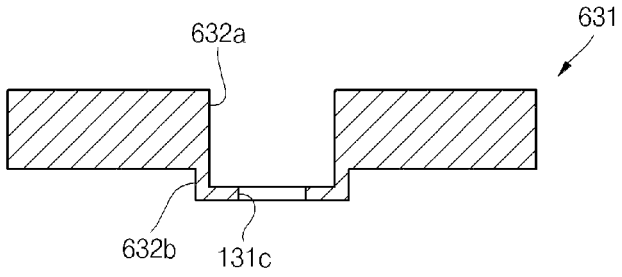


FIG. 16



SECONDARY BATTERY

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to and the benefit of Korean Patent Application No. 10-2011-0015530, filed on Feb. 22, 2011, the entire content of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Embodiments of the present invention relate to a secondary battery.

2. Description of the Related Art

A secondary battery is reusable because it can be charged and recharged. Due to its reusability, the secondary battery may be employed as a power source for a computer (e.g., a notebook computer or a laptop computer), a portable communication device (e.g., a mobile phone and a camcorder), etc.

Electric vehicles have been under development to reduce the environmental pollution due to exhaust gas from vehicles utilizing internal combustion engines. In order to apply the secondary battery to an electric vehicle, the development of an economical, high-speed chargeable, stable, and high-energy capacity secondary battery is desired.

A secondary battery can often be classified as either a lead battery, a nickel/cadmium (Ni/Cd) battery, a nickel/metal hydride (Ni/MH) battery or a lithium ion battery according to its negative electrode material and/or positive electrode material. Potential and energy density of the secondary battery is determined by properties of the electrode material. The lithium ion battery with its lithium electrode material can be used as a power source for a portable electronic device and for an electric vehicle because the energy density of lithium is relatively high due to a low redox potential and low molecular weight.

However, when the secondary battery is incorporated into a product, it is exposed to external impacts during use. Accordingly, a secondary battery having improved stability under external impacts is needed.

SUMMARY OF THE INVENTION

Embodiments of the present invention provide a secondary battery capable of inhibiting an internal electric short by allowing an upper cap plate to be deformed toward the outside of a can and having improved stability under external impacts.

According to an embodiment of the present invention, a secondary battery is provided, including a can having an internal space, an electrode assembly inserted into the space of the can, and a cap plate coupled to a top portion of the can, wherein the cap plate includes a deformation inducing part having a groove formed on its one surface.

The deformation inducing part may be thinner than other regions of the cap plate.

The groove forming the deformation inducing part may be formed to a depth of 20% to 80% based on a thickness of the cap plate.

The deformation inducing part may be formed on a top surface of the cap plate.

In addition, the deformation inducing part may be formed on one surface of the cap plate along at least one direction of a lengthwise direction and a widthwise direction of the cap plate, or a combination thereof.

Further, the deformation inducing part may be formed to extend from one end to the other end of an entire surface of the cap plate along at least one direction of a lengthwise direction and a widthwise direction of the cap plate, or a combination thereof.

In addition, the deformation inducing part formed along the lengthwise direction of the cap plate may be centrally formed based on the width of the cap plate.

The deformation inducing part formed along the widthwise direction of the cap plate is centrally formed based on the length of the cap plate.

In addition, the deformation inducing part formed along the widthwise direction of the cap plate may include a plurality of deformation inducing parts.

The deformation inducing parts formed along the widthwise direction of the cap plate may be disposed to be symmetrical in view of the center of the length of the cap plate.

In addition, the deformation inducing part may include a groove formed along the lengthwise direction of the cap plate and one or more support portions formed across the center of the groove.

The support portion and the cap plate may have the same thickness.

In addition, the support portion may be formed to be perpendicular to lengthwise direction of the groove.

The deformation inducing part may form a lower portion of the groove and may further include a protrusion extending from the cap plate.

The protrusion may extend toward a bottom surface of the cap plate.

In addition, the protrusion may have a smaller thickness than other regions of the cap plate.

A protruding height of the protrusion extending from the cap plate may be 70% or less based on a depth of the groove.

The deformation inducing part may further include at least one notch formed along the groove in parallel.

The notch may include a plurality of notches formed to be symmetrical with respect to the groove.

As described above, since the secondary battery according to the embodiment of the present invention includes a deformation inducing part shaped of a groove formed by engraving a top surface of a cap plate, the cap plate is deformed to protrude upwardly under external impacts such that it is bent along the deformation inducing part, thereby inhibiting internal components of a can from being electrically short-circuited, ultimately increasing the stability of the secondary battery.

In addition, the secondary battery according to the embodiment of the present invention includes a protrusion that separates a groove of the deformation inducing part or a support portion forming a lower portion of a groove and extending toward a bottom surface of the cap plate, thereby allowing the cap plate to be deformed only when an external pressure exceeds a reference pressure, ultimately improving the reliability of the secondary battery.

Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects, features and advantages of the present invention will be more apparent from the following detailed description in conjunction with the accompanying drawings, in which:

FIG. **1** is a perspective view illustrating a secondary battery according to an embodiment of the present invention;

FIG. **2** is an exploded perspective view illustrating the secondary battery shown in FIG. **1**;

FIG. **3** is a plan view illustrating a cap plate of the secondary battery shown in FIG. **1**;

FIG. **4** is a cross-sectional view illustrating a state in which an electrode terminal is coupled to the cap plate of the secondary battery shown in FIG. **1**;

FIG. **5**A illustrates a direction in which external impacts are applied to the secondary battery shown in FIG. **1**;

FIG. **5**B illustrates that the cap plate is bent due to the external impacts applied to the secondary battery shown in FIG. **1**;

FIG. **6** is a perspective view illustrating a cap plate of a secondary battery according to another embodiment of the present invention;

FIG. **7** is a plan view illustrating the cap plate shown in FIG. **6**;

FIG. **8** is a perspective view illustrating a cap plate of a secondary battery according to still another embodiment of the present invention;

FIG. **9** is a plan view illustrating the cap plate shown in FIG. **8**;

FIG. **10** is a cross-sectional view illustrating the cap plate shown in FIG. **8**;

FIG. **11** is a perspective view illustrating a cap plate of a secondary battery according to still another embodiment of the present invention;

FIG. **12** is a cross-sectional view illustrating the cap plate shown in FIG. **11**;

FIG. **13** is a perspective view illustrating a cap plate of a secondary battery according to still another embodiment of the present invention;

FIG. **14** is a plan view illustrating the cap plate shown in FIG. **13**;

FIG. **15** is a perspective view illustrating a cap plate of a secondary battery according to still another embodiment of the present invention; and

FIG. **16** is a cross-sectional view illustrating the cap plate shown in FIG. **15**.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings such that they can easily be made and used by those skilled in the art.

A configuration of a secondary battery according to an embodiment of the present invention will now be described. FIG. **1** is a perspective view illustrating a secondary battery according to an embodiment of the present invention, FIG. **2** is an exploded perspective view illustrating the secondary battery shown in FIG. **1**, FIG. **3** is a plan view illustrating a cap plate of the secondary battery shown in FIG. **1**, and FIG. **4** is a cross-sectional view illustrating a state in which an electrode terminal is coupled to the cap plate of the secondary battery shown in FIG. **1**.

Referring to FIGS. **1** to **4**, the secondary battery **100** according to the embodiment of the present invention includes a can **110**, an electrode assembly **120**, and a cap assembly **130**.

The can **110** has a substantially rectangular parallelepiped shape. The can **110** has an internal space and a top opening. The can **110** may be made of aluminum (Al), iron (Fe), or alloys thereof. In addition, the can **110** may have an inner surface that is electrically insulated. The can **110** includes a groove **111** formed along its upper periphery so that an insulation case **129** of the cap assembly **130** is safety mounted in the groove **111**.

The electrode assembly **120** is inserted into the space of the can **110**. The electrode assembly **120** includes a positive electrode plate **121** on which a positive electrode active material (not shown) such as lithium cobalt oxide (LiCoO2) is coated, a negative electrode plate **122** on which a negative electrode active material (not shown) such as graphite is coated, and a separator **123** disposed between the positive electrode plate **121** and the negative electrode plate **122** to prevent or reduce electric shorts and to enable movement of lithium ions. The positive electrode plate **121**, the negative electrode plate **122**, and the separator **123** are wound several times into a jelly roll shape, and then accommodated in the can **110**. The positive electrode plate **121** may be made of aluminum (Al) foil, the negative electrode plate may be made of copper (Cu) foil, and the separator **123** may be made of polyethylene (PE) or polypropylene (PP).

An upwardly extended positive lead **121***a* is coupled to the positive electrode plate **121**, and an upwardly extended negative lead **122***a* is coupled to the negative electrode plate **122**. The positive lead **121** a may be made of aluminum (Al), and the negative lead **122***a* may be made of nickel (Ni).

An electrolyte (not shown) is injected into the can **110**, and is positioned between the positive electrode plate **121** and the negative electrode plate **122** of the electrode assembly **120**. The electrolyte may be a non-aqueous organic electrolyte such as a mixture of lithium salt and highly pure organic solvents. Further, the electrolyte may be made of polymeric materials. The electrolyte serves as a medium through which lithium ions are generated due to the electrochemical reactions between the positive electrode plate **121** and the negative electrode plate **122** during charging and discharging of the battery move.

An insulating case **129** may additionally be coupled to the opening **116** of the can **110** at the top of the electrode assembly **120**. A lead through-hole **129***a* may be formed in the insulation case **129** such that the negative electrode lead **122***a* passes through the lead hole **129***a*. An electrolyte inlet **129***b* may be formed in the insulation case **129** such that an electrolyte injected through the cap plate **131** may easily flow into the electrode assembly **120**.

The cap assembly **130** is coupled to a top portion of the can **110**. The cap plate **131** is generally formed to a thickness of 1 mm to 1.5 mm. The cap assembly **130** includes the cap plate **131**, a plug **133**, an insulation gasket **134**, an electrode terminal **135**, an insulation plate **136**, and a terminal plate **137**.

Specifically, the cap plate **131** is coupled to the opening of the can **110** and has a plate shape with long and short sides. When the cap plate **131** is coupled to the opening of the can **110**, a peripheral portion of the cap plate **131** is welded to seal the can **110**.

The cap plate **131** includes a deformation inducing part **132** formed lengthwise on a top surface opposite to a surface facing the can **110**. The deformation inducing part **132** is formed by forming a groove on a portion of the top surface of the cap plate **131**. That is to say, the deformation inducing part **132** is thinner than other regions of the cap plate **131**. Since the deformation inducing part **132** is relatively thin along the lengthwise direction of the cap plate **131**, the cap plate **131** is more likely to be bent about the center of the deformation inducing part **132** when external impacts are applied in the widthwise direction of the cap plate **131**. That is to say, when the deformation inducing part **132** is bent, this results in the deformation allowing the cap plate **131** to protrude outwardly from the top portion of the can **110**, so that the cap plate **131**

contacts the electrode assembly **120** positioned inside the can **110**. Accordingly, the electrode assembly **120** is inhibited from being electrically short-circuited. Therefore, the secondary battery **100** according to the embodiment of the present invention, can inhibit internal electric shorts even under external impacts, thereby improving the electrical reliability of the battery.

Alternatively, the deformation inducing part **132** may be formed along the entire length of the cap plate **131**. That is to say, the deformation inducing part **132** may be formed to extend from one end to the other end of the cap plate **131** along the lengthwise direction of the cap plate **131**. In this case, since the deformation inducing part **132** may serve as a guide for deformation of the cap plate **131**, the cap plate **131** may be easily bent along the deformation inducing part **132** under external impacts that are applied widthwise.

The groove forming the deformation inducing part **132** may be formed to a depth of 20% to 80% based on a thickness of the cap plate **131**. If the groove forming the deformation inducing part **132** is formed to a depth of greater than or equal to 20% to up to 80%, the deformation inducing part **132** can more easily induce deformation of the cap plate **131**. If the groove forming the deformation inducing part **132** is formed to a depth of smaller than or equal to 80%, the cap plate **131** can be prevented from being deformed thereby securing durability and reliability.

The cap plate **131** includes an electrolyte injection hole **131***a* for injecting an electrolyte into the can **110** at one side of the deformation inducing part **132**. The electrolyte injection hole **131***a* is coupled to the plug **133** which seals the the electrolyte injection hole **131***a*. Further, the cap plate **131** includes a safety vent **131***b* that is relatively thin provided at the other side of the deformation inducing part **132**.

The safety vent **131***b* is opened when the internal gas pressure of the can **110** exceeds a reference pressure, releasing the gas, thereby improving the safety of the can **110**.

In addition, the cap plate **131** includes a hole **131***c* formed roughly at the center of the deformation inducing part **132**. The hole **131***c* is coupled to the insulation gasket **134**.

The electrode terminal **135** and the insulation gasket **134** are engaged with a hole **134***a* formed in the insulation gasket **134**. A lower portion **135***a* of the electrode terminal **135** may pass through the hole **134***a* of the insulation gasket **134** and the hole **131***c* of the cap plate **131** to then be connected to the negative electrode lead **122***a*. The positive electrode lead **121***a* may be connected to the lower surface of the cap plate **131**, or vice versa.

The insulation plate **136** is positioned on the lower surface of the cap plate **131**, and the electrode terminal **135** is engaged with a hole **136***c* of the insulation plate **136**. The lower portion **135***a* of the electrode terminal **135** passes through the hole **136***c* of the electrode terminal **135**.

The terminal plate **137** is positioned on the lower surface of the insulation plate **136**. The electrode terminal **135** is engaged with the hole **137***a* of the terminal plate **137**, and the electrode terminal **135** is electrically connected to the negative electrode lead **122***a*.

Hereinafter, an operation in which the cap plate is bent when external impacts are applied to the secondary battery according to the embodiment of the present invention is described in more detail.

FIG. **5**A illustrates a direction in which external impacts are applied to the secondary battery shown in FIG. **1**, and FIG. **5**B illustrates that the cap plate is bent due to the external impacts applied to the secondary battery shown in FIG. **1**.

Referring first to FIG. **5**A, pressures derived from external impacts are applied in a widthwise direction of the secondary battery **100** according to the embodiment of the present invention. The pressures are transferred to the cap plate **131** along directions indicated by arrows.

Referring to FIG. **5**B, the cap plate **131** is bent due to the pressure. Here, the cap plate **131** is bent such that left and right sides of the cap plate **131** are folded about the deformation inducing part **132**. This is because the deformation inducing part **132** is thinner than other regions of the cap plate **131**. The deformation inducing part **132** is bent by the externally applied pressure. Accordingly, a region where the deformation inducing part **132** of the cap plate **131** is formed may protrude outward from the upper end of the can **110**. Since the cap plate **131** protrudes outward from the top portion of the can **110** formed under the cap plate **131**, the electrode assembly **120** positioned inside the cap plate **131** can be inhibited from being short-circuited from the can **110**. Therefore, as described above, even when the pressure derived external impacts are applied, the electrical reliability of the secondary battery **100** can be improved.

A configuration of a secondary battery according to still another embodiment of the present invention will now be described.

FIG. **6** is a perspective view illustrating a cap plate of a secondary battery according to another embodiment of the present invention and FIG. **7** is a plan view illustrating the cap plate shown in FIG. **6**.

In this embodiment of the present invention, the same functional components as those of the previous embodiment are denoted by the same reference numerals, and the following description will focus on differences between the two embodiments.

Referring to FIGS. **6** and **7**, the secondary battery according to the embodiment of the present invention includes a can, an electrode assembly, and a cap assembly.

The cap assembly includes a cap plate **231**. The cap assembly may also include a plug, an insulation gasket, an electrode terminal, an insulation plate, and a terminal plate, which are substantially the same as those of the previous embodiment, and a detailed description thereof will be omitted.

The cap plate **231** includes a deformation inducing part **232** formed lengthwise on its top surface. The deformation inducing part **232** is formed on a portion of the top surface of the cap plate **231** to be thinner than other regions of the cap plate **231**.

The deformation inducing part **232** includes a groove **232***a* formed lengthwise in the cap plate **231**, and a support portion **232***b* formed widthwise in the cap plate **231**.

Like in the previous embodiment, the groove **232***a* may be formed along the lengthwise direction of the cap plate **231**. When an external pressure is applied to the cap plate **231**, the cap plate **231** is bent about the groove **232***a*, thereby inhibiting internal components of the can from being short-circuited.

The support portion **232***b* may be formed to be perpendicular to the groove **232***a* along the lengthwise direction of the cap plate **231**. The support portion **232***b* includes one or more support portions and may be arranged along the groove **232***a*.

That is to say, the support portion **232***b* includes one or more support portions at the groove **232***a* of the cap plate **231** such that the groove **232***a* is formed in a disconnected shape. The support portion **232***b* may have the same thickness as a region other than the groove **232***a* in the cap plate **231**. The support portion **232***b* allows the deformation inducing part **232** to withstand a reference pressure by securing the strength of the deformation inducing part **232** even though an overall deformation of the deformation inducing part **232** is a little restricted. That is to say, the support portion **232***b* allows the deformation inducing part **232** to withstand an external pres-

sure until the reference pressure is reached. In addition, when the external pressure exceeds the reference pressure, the deformation inducing part **232** may be deformed through the groove **232***a*.

A configuration of a secondary battery according to still another embodiment of the present invention will now be described.

FIG. **8** is a perspective view illustrating a cap plate of a secondary battery according to still another embodiment of the present invention, FIG. **9** is a plan view illustrating the cap plate shown in FIG. **8**, and FIG. **10** is a cross-sectional view illustrating the cap plate shown in FIG. **8**.

Referring to FIGS. **8** to **10**, the secondary battery according to the embodiment of the present invention includes a can, an electrode assembly, and a cap assembly.

The cap assembly includes a cap plate **331**. The cap assembly includes a plug, an insulation gasket, an electrode terminal, an insulation plate, and a terminal plate, which are substantially the same as those of the previous embodiment, and a detailed description thereof will be omitted.

The cap plate **331** includes a deformation inducing part **332** having a groove **332***a* and at least one notch **332***b* formed in parallel with the groove **332***a*, formed lengthwise. The groove **332***a* of the deformation inducing part **332** is substantially the same as that of the previous embodiment.

The notch **332***b* includes one or more notches to be parallel with the groove **332***a*. Since the notch **332***b* is substantially parallel with the groove **332***a*, it can be more easily deformed when an external pressure is applied to a top portion of the cap plate **331**. For example, in the embodiment of the present invention in which the notch **332***b* is formed at opposing sides of the groove **332***a*, when external pressures of opposing widthwise directions are asymmetrically applied to the cap plate **331**, the cap plate **331** is first bent at the notch **332***b* positioned closer to the external pressure applied, thereby inducing the overall deformation of the cap plate **331**. In addition, the cap plate **331** is upwardly bent at the notch **332***b* as well as at the groove **332***a*, thereby achieving deformation of the cap plate **331** uniformly over the top surface of the cap plate **331**. Therefore, deformation of the cap plate **331** derived from the pressure applied to the cap plate **331** can be dispersed, thereby more effectively preventing internal components of the can from being short-circuited.

A configuration of a secondary battery according to still another embodiment of the present invention will now be described.

FIG. **11** is a perspective view illustrating a cap plate of a secondary battery according to still another embodiment of the present invention and FIG. **12** is a cross-sectional view illustrating the cap plate shown in FIG. **11**.

Referring to FIGS. **11** to **12**, the secondary battery according to the embodiment of the present invention includes a can, an electrode assembly, and a cap assembly.

The cap assembly includes a cap plate **431**. The cap assembly includes a plug, an insulation gasket, an electrode terminal, an insulation plate, and a terminal plate, which are substantially the same as those of the previous embodiment, and a detailed description thereof will be omitted.

The cap plate **431** includes a deformation inducing part **432** formed in the widthwise direction.

Unlike in the previous embodiment, in this embodiment of the present invention, the deformation inducing part **432** is formed in the widthwise direction of the cap plate **431**, that is, in a short side direction of the deformation inducing part **432** based on the long side of the cap plate **431**. If an external pressure is applied in the lengthwise direction of the cap plate **431**, the deformation inducing part **432** causes the cap plate **431** to be bent. Specifically, the deformation inducing part **432** allows the cap plate **431** to be upwardly bent, thereby inhibiting internal components of the can from being short-circuited. In addition, the deformation inducing part **432** is formed along the entirely widthwise direction. That is to say, the deformation inducing part **432** extends from one end to the other end along the widthwise direction of the cap plate **431**, thereby allowing the cap plate **431** to be easily bent.

A configuration of a secondary battery according to still another embodiment of the present invention will now be described.

FIG. **13** is a perspective view illustrating a cap plate of a secondary battery according to still another embodiment of the present invention and FIG. **14** is a plan view illustrating the cap plate shown in FIG. **13**.

Referring to FIGS. **13** and **14**, the secondary battery according to the embodiment of the present invention includes a cap assembly having a cap plate **531**.

The cap plate **531** includes a deformation inducing part **532** having a first groove **532***a* formed lengthwise and a second groove **532***b* formed widthwise.

The first groove **532***a* of the deformation inducing part **532** is formed along the lengthwise direction of the cap plate **531**, that is, in parallel with the long side direction of the cap plate **531**. The first groove **532***a* is deformed when an external pressure is applied to the cap plate **531** widthwise, that is, in parallel with the short side of the cap plate **531**. In this case, the cap plate **531** is bent along the first groove **532***a*, thereby preventing the electrode assembly positioned in the can from being short-circuited.

The second groove **532***b* is formed along the widthwise direction of the cap plate **531**, that is, in parallel with the short side of the cap plate **531**. The second groove **532***b* is deformed when an external pressure is applied to the cap plate **531** lengthwise, that is, in parallel with the long side of the cap plate **531**. In this case, the cap plate **531** is bent along the second groove **532***b*, thereby preventing the electrode assembly positioned in the can from being short-circuited.

Therefore, the cap plate **531** is bent along the first groove **532***a* and the second groove **532***b* causing the deformation inducing part **532** to then upwardly protrude, thereby inhibiting internal components of the can from being short-circuited.

A configuration of a secondary battery according to still another embodiment of the present invention will now be described.

FIG. **15** is a perspective view illustrating a cap plate of a secondary battery according to still another embodiment of the present invention, and FIG. **16** is a cross-sectional view illustrating the cap plate shown in FIG. **15**.

Referring to FIGS. **15** and **16**, the secondary battery according to the embodiment of the present invention includes a cap assembly having a cap plate **631**.

The cap plate **631** includes a deformation inducing part formed lengthwise. The deformation inducing part includes a groove **632***a* formed on a top surface of the cap plate **631** and a protrusion **632***b* formed under the groove **632***a* and downwardly protruding from the cap plate **631**.

The groove **632***a* of the embodiment of the present invention, forming the deformation inducing part **631**, performs the same function as in the previous embodiment.

The protrusion **632***b* forms a lower portion of the groove **632***a*. The protrusion **632***b* protrudes toward a bottom surface of the cap plate **631**. The protrusion **632***b* secures the overall strength of the cap plate **631**. Therefore, the protrusion **632***b* allows the cap plate **631** to be deformed only when an external pressure applied to the cap plate **631** exceeds a reference

pressure while allowing the cap plate **631** to withstand the external pressure until the reference pressure is reached. The cap plate **631** is bent about the protrusion **632***b* and is deformed such that the center of the cap plate **631** upwardly protrudes. Therefore, as described above, it is possible to more easily prevent internal components of the can from being short-circuited.

A protruding height of the protrusion **632***b* extending from the cap plate **631** may be 70% or less based on a depth of the groove **632***a*. When the protrusion **632***b* is 70% or less based on the depth of the groove **632***a*, the protrusion **632***b* is more easily formed in the cap plate **631**, thereby increasing the manufacturability. In addition, since the groove **632***a* is formed on the protrusion **632***b*, the protrusion **632***b* allows the cap plate **631** to be more easily bent as long as the protrusion **632***b* protrudes from the bottom surface of the cap plate **631**.

While this invention has been described in connection with what is presently considered to be practical exemplary embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but, rather is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

What is claimed is:

1. A secondary battery comprising:

a can having an internal space;

an electrode assembly inserted into the internal space of the can; and

a cap plate coupled to a top portion of the can having a width and a length,

wherein the cap plate includes a deformation inducing part formed by a groove formed on a surface of the cap plate, wherein the groove extends the entire length of the cap plate, and wherein the cap plate includes an opening for the electrode that is formed in the groove.

2. The secondary battery of claim **1**, wherein the deformation inducing part is thinner than other regions of the cap plate.

3. The secondary battery of claim **1**, wherein the groove forming the deformation inducing part is formed to a depth of 20% to 80% based on a thickness of the cap plate.

4. The secondary battery of claim **1**, wherein the deformation inducing part is formed on a top surface of the cap plate.

5. The secondary battery of claim **1**, wherein the deformation inducing part is formed on one surface of the cap plate along at least one direction of a lengthwise direction and a widthwise direction of the cap plate, or a combination thereof.

6. The secondary battery of claim **5**, wherein the deformation inducing part is formed to extend from one end to the other end of an entire surface of the cap plate along at least one direction of a lengthwise direction and a widthwise direction of the cap plate, or a combination thereof.

7. The secondary battery of claim **5**, wherein the deformation inducing part formed along the lengthwise direction of the cap plate is centrally formed based on the width of the cap plate.

8. The secondary battery of claim **5**, wherein the deformation inducing part formed along the widthwise direction of the cap plate is centrally formed based on the length of the cap plate.

9. The secondary battery of claim **5**, wherein the deformation inducing part formed along the widthwise direction of the cap plate includes a plurality of deformation inducing parts.

10. The secondary battery of claim **9**, wherein the deformation inducing parts formed along the widthwise direction of the cap plate are disposed to be symmetrical in view of the center of the length of the cap plate.

11. The secondary battery of claim **1**, wherein the deformation inducing part includes a groove formed along the lengthwise direction of the cap plate and one or more support portions formed across the center of the groove.

12. The secondary battery of claim **11**, wherein the support portion and the cap plate have the same thickness.

13. The secondary battery of claim **11**, wherein the support portion is formed to be perpendicular to the lengthwise direction of the groove.

14. The secondary battery of claim **1**, wherein the deformation inducing part forms a lower portion of the groove and further includes a protrusion extending from the cap plate.

15. The secondary battery of claim **14**, wherein the protrusion extends toward a bottom surface of the cap plate.

16. The secondary battery of claim **14**, wherein the protrusion has a smaller thickness than other regions of the cap plate.

17. The secondary battery of claim **14**, wherein a protruding height of the protrusion extending from the cap plate is 70% or less based on a depth of the groove.

18. The secondary battery of claim **1**, wherein the deformation inducing part further includes at least one notch formed along the groove in parallel.

19. The secondary battery of claim **18**, wherein the notch includes a plurality of notches formed to be symmetrical with respect to the groove.

20. A secondary battery comprising:

a can having an internal space;

an electrode assembly inserted into the internal space of the can; and

a cap plate having a length and a width coupled to a top portion of the can, wherein the cap plate is contoured to have a groove that extends the entire length of the cap plate such that external forces exerted against the can results in the cap plate deforming in a first direction away from the top portion of the can, and wherein the cap plate includes an opening for the electrode that is formed in the groove.

21. The secondary battery of claim **20**, wherein the cap plate is contoured so as to be deformed in the first direction in response to pressures above a reference threshold.

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